Fish diets and food webs in the Northwest Territories: bull trout (*Salvelinus confluentus*)

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FISH DIETS AND FOOD WEBS IN THE NORTHWEST TERRITORIES: BULL TROUT (*Salvelinus confluentus*)

by

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ABSTRACT

Stewart, D.B., Mochnacz, N.J., Sawatzky, C.D., Carmichael, T.J., and Reist, J.D. 2007. Fish diets and food webs in the Northwest Territories: bull trout (*Salvelinus confluentus*). Can. Manuscr. Rep. Fish. Aquat. Sci. 2800: vi + 18 p.

Younger bull trout prey opportunistically on a wide variety of seasonally available macroinvertebrate taxa and life stages that originate from aquatic and terrestrial habitats. Juveniles become increasingly piscivorous as they approach adulthood; with adult populations in some lakes being highly piscivorous. Humans are important predators on adult and large juvenile bull trout while piscivorous fishes, particularly lake trout (*Salvelinus namaycush*) and large bull trout, may be the key predators on smaller juveniles. Competition for food with other species of trout and salmon may be a factor in the displacement of bull trout from some lake habitats, and limit their growth in some stream habitats. This document provides a generalized food web for the bull trout, and reviews knowledge of its interactions with predators, prey, and competitors. Dietary differences related to geographical location, habitat type, life history stage, season, predation, and competition are discussed.

Key words: diet; life history; habitat use; fresh water; fluvial; adfluvial; stream resident; feeding behaviour; Salmonidae.

RÉSUMÉ

Stewart, D.B., Mochnacz, N.J., Sawatzky, C.D., Carmichael, T.J., and Reist, J.D. 2007. Fish diets and food webs in the Northwest Territories: bull trout (*Salvelinus confluentus*). Can. Manuscr. Rep. Fish. Aquat. Sci. 2800: vi + 18 p.

Les jeunes individus de l'omble à tête plate s'alimentent de façon opportuniste d'une vaste gamme de macroinvertébrés d'origine aquatique ou terrestre qui se présentent selon les saisons et le stade du cycle vital. Ils deviennent de plus en plus piscivores à mesure qu'ils approchent de la maturité. Dans certains lacs, les adultes sont hautement piscivores. L'homme est un important prédateur de l'omble à tête plate adulte et juvénile, tandis que des poissons piscivores, le touladi (*Salvelinus namaycush*) en particulier et les grands individus de l'omble à tête plate, peuvent être de grands prédateurs des juvéniles de petite taille. La compétition pour la nourriture avec d'autres espèces de truite et de saumon peut mener au déplacement de l'omble à tête plate de certains habitats lacustres et limiter sa croissance dans certains habitats fluviaux. Nous présentons un réseau trophique généralisé pour l'omble à tête plate et nous évaluons les connaissances sur ses interactions avec ses prédateurs, ses proies et ses compétiteurs. Nous examinons également les différences dans son alimentation reliées aux emplacements géographiques, aux types d'habitat, aux stades du cycle vital, aux saisons, à la prédation et à la compétition.

Mots clés : régime alimentaire; cycle vital; utilisation d'habitat; eau douce; sédentaire; fluvial; adfluvial; Salmonidés; comportement alimentaire.

1.0 INTRODUCTION

Renewed interest in natural gas pipeline development along the Mackenzie Valley has raised the prospect that fish species in the watershed may be impacted by changes to their habitat. The proposed pipeline would extend from near the Beaufort Sea coast to markets in the south (http://www.mackenziegasproject.com/). Fishes in the Mackenzie River depend upon the integrity of their aquatic habitats, so it is important to summarize knowledge that can be used to assess potential impacts of this development proposal and others, and to facilitate efforts to avoid and mitigate these impacts.

This report reviews knowledge of the diet of the bull trout, *Salvelinus confluentus* (Suckley, 1859). This attractive sport fish is distributed from the southern Yukon and southwestern Northwest Territories south to northern California and Nevada, and from the Pacific coast east to eastern Alberta (Haas and McPhail 2001; Mochnacz 2002). Stream resident, **fluvial**[1], and **adfluvial** life history types of the species occur in the Mackenzie River watershed upstream from the Ramparts, but have not been reported elsewhere in the Northwest Territories.

Very little is known of the species' diet within the Mackenzie watershed, particularly outside the summer season. This limits the ability to assess the effects of environmental changes on the species, particularly impacts related to pipeline development and climate change. This report presents a generic food web for bull trout, based largely on data from outside the Northwest Territories, and discusses how it may be applied to bull trout populations in the Mackenzie River basin. It reviews knowledge of how the species' diet varies with geographical location, habitat type, season, life history stage, and competition. It also considers predation pressures and identifies knowledge gaps. Similar reports have been prepared for other fishes that inhabit the Mackenzie River watershed. Stewart *et al.* (2007) provide a recent review of habitat use by bull trout.

2.0 FOOD WEB

Quantitative data from bull trout populations in Washington (WA), Montana (MT), British Columbia (BC), and Alberta (AB) were used to construct the generic food web (Appendix 1; Appendix 2). Most of these studies were conducted during the summer, and small sample sizes often resulted in lumping together of juvenile and adult dietary data. These limitations make it difficult to compare dietary differences among populations, life stages, and seasons. They also limit what can be said about the energetic importance of each pathway.

[1] Terms in bold type are defined in the Glossary.

The methods used to quantify bull trout diet are not readily comparable among studies. Some studies have used percentage wet weight to quantify stomach contents, while others have used percent by volume or percent taxonomic composition. Yet others have used variations of the points method (Hynes 1950) or calculated indices of relative importance (IRI) (George and Hadley 1979) that consider both volume and frequency of occurrence of prey items in the diet. Some studies have examined the stomachs of dead fish; others used gastric lavage, which washes the gut contents out of live fish but is not always 100% efficient. The results have been variously expressed as percentages or total points. To facilitate rough comparisons among studies, point totals were converted to percentages before their inclusion in the Appendices.

Based on these data, a generalized food web has been constructed for the species (Figure 1). Aspects of this food web, including predators and dietary differences related to life history stage, habitat, and season are discussed below, as are the effects of interspecific competition.

2.1 Predators

Mink (*Mustela vison*), bears (*Ursus* spp.), osprey (*Pandion haliaetus*), and river otter (*Lontra canadensis*) prey on adult bull trout (Stelfox 1997; Jakober *et al.* 1998; Chandler *et al.* 2001). These species likely prey also on larger juveniles. Adult bull trout prey upon smaller juveniles, as will other larger **piscivorous** fishes such as lake trout, and piscivorous birds. Bull trout eggs are likely eaten by a variety of invertebrates and fishes, including rainbow trout (*Oncorhynchus mykiss*) (Boag 1987).

The aggressive feeding habits of larger juvenile and adult bull trout make them very vulnerable to harvest by angling (Geotz 1989; Brown 1992; Stelfox and Egan 1995; McPhail and Baxter 1996; Mushens and Post 2000; Olmsted *et al.* 2001). Bull trout are sensitive to exploitation because their populations are small and individuals are slow-growing, late to mature, and spawn in non-consecutive years (Carl *et al.* 1989; Clayton 2001; Post and Johnston 2002). Populations that are readily accessible to harvesters typically require strict regulation and careful management to avoid overexploitation (Donald and Stelfox 1997).

2.2 Prey

Bull trout are opportunistic predators that alter their diet in response to seasonal abundance of prey (Brown 1992, 1994) (Figure 1). Dietary differences among fish at different life history stages, in lake or stream environments, at different latitudes or elevations, and during the year are discussed below (Appendices 1 and 2).

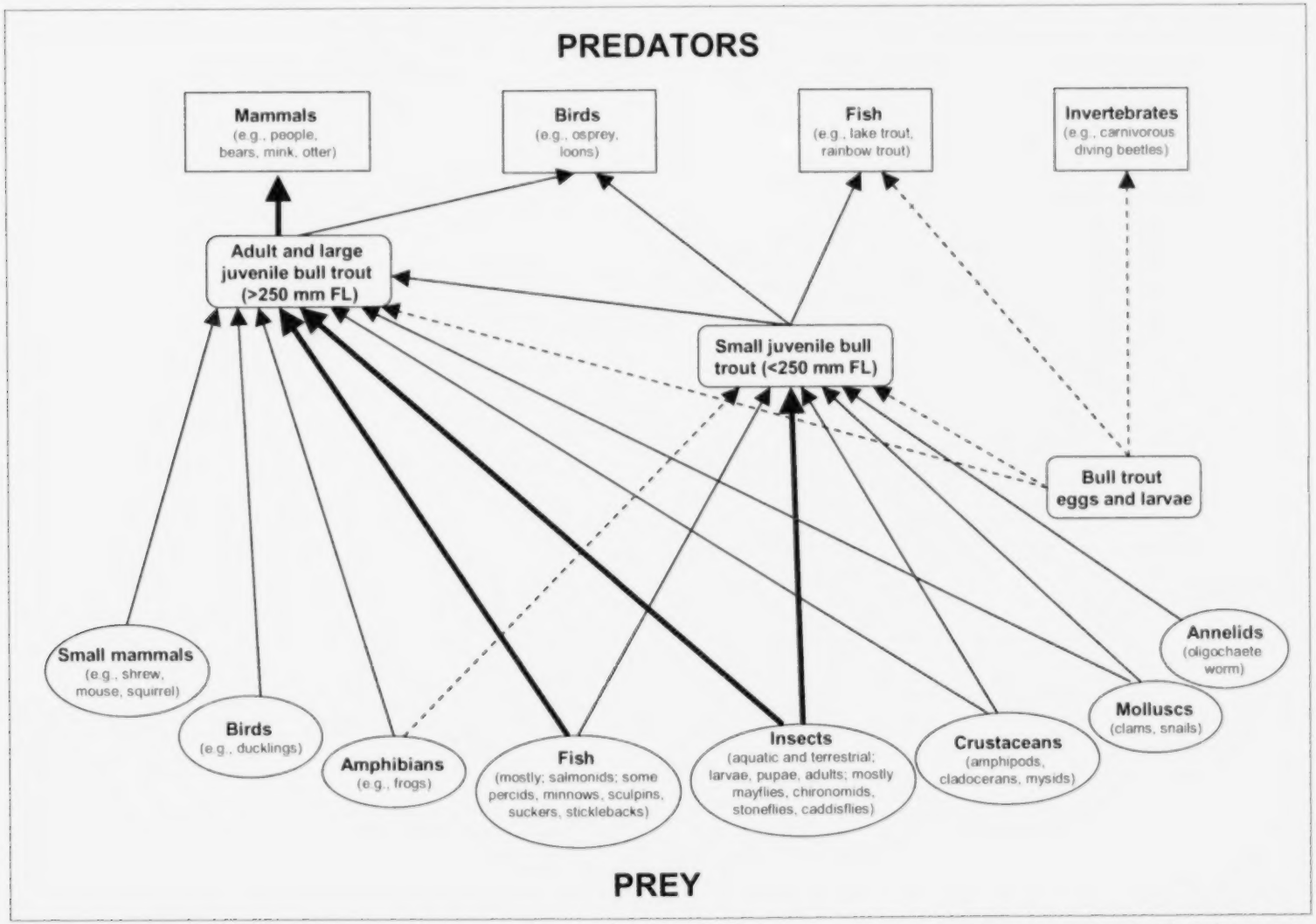

Figure 1. Generalized food web for bull trout showing the direction of energy flow. Bold lines indicate major food pathways, in comparison to thinner lines; solid lines indicate demonstrated and dashed lines putative pathways.

2.2.1 Life history stages

Juvenile bull trout eat a wide variety of **macroinvertebrate** taxa and life stages (eggs, larvae, pupae, nymphs, adults) originating from both aquatic and terrestrial habitats (Underwood *et al.* 1995). Insects, particularly mayflies, midges (chironomids), stoneflies, and caddisflies are important prey during the summer in both lakes and streams (Hagen and Baxter 1992; Nakano *et al.* 1992; Underwood *et al.* 1995). Comparisons of their diet with prey availability suggest that prey selection is random and related to availability (Underwood *et al.* 1995). In summer, juvenile bull trout in the Mackenzie River watershed eat aquatic and terrestrial insects (e.g., grasshopper) and insect larvae (Mochnacz *et al.* 2004).

In lake and stream environments, juvenile bull trout forage more on drift during the day and on benthic organisms at night (Nakano *et al.* 1992; Bonneau and Scarnecchia 1998; Hagen and Taylor 2001). Little if any surface foraging has been observed. Bull trout have a larger gape and consume relatively larger prey than **sympatric** Dolly Varden (*Salvelinus malma*) of the same size, which eat a higher proportion of adult winged insects (Hagen and Taylor 2001). As juvenile bull trout grow larger, they prey upon larger items and the proportion of fish in their diet increases (McPhail and Baxter 1996). In the presence of other fish species, the shift to piscivory takes place at between 100 and 200 mm (Stewart *et al.* 1982; Boag 1987; Hagen and Baxter 1992; Pratt 1992). Growth spurts may occur as fish shift to larger prey (McPhail and Murray 1979; Craig and Bruce 1982).

Adult bull trout will also eat a wide variety of invertebrates but often prey heavily on other fishes (Boag 1987; Connor *et al.* 1997; Wilhelm *et al.* 1999; Mochnacz *et al.* 2004). In the Mackenzie River watershed, fish such as slimy sculpin (*Cottus cognatus*), longnose sucker (*Catostomus catostomus*), Arctic grayling (*Thymallus arcticus*), and smaller bull trout are eaten (Mochnacz *et al.* 2004). Cannibalism has been documented in bull trout populations (Cavender 1978; Leathe and Graham 1981; Wilhelm *et al.* 1999; Mochnacz *et al.* 2004).

Bull trout tend to be increasingly piscivorous with size, and are almost exclusively so in some lakes (Leathe and Graham 1981; Fraley and Shepard 1989; Hagen and Baxter 1992; Stelfox and Egan 1995; Mushens and Post 2000). Indeed, adfluvial bull trout from Kootenay Lake, BC migrate downstream into the lower Duncan River in autumn to feed on spawning kokanee salmon (*Oncorhynchus nerka*) (Olmsted *et al.* 2001). Kokanee are also a major food item for bull trout in Pend Oreille Lake, Idaho (Jeppson and Platts 1959). Given the opportunity, bull trout will also eat suitably sized frogs, snakes, ducklings and small mammals (e.g., shrews, squirrels, and mice) (Brown 1971; Cavender 1978; Goetz 1989).

2.2.2 Lake and stream habitats

Dietary variations have been observed among local populations of bull trout. These differences are likely related to the availability of prey species.

In the upper reaches of Alberta's Muskeg River, for example, juvenile and adult bull trout resident above a beaver dam complex appeared to be insectivorous, despite the presence of juvenile and adult rainbow trout (*Oncorhynchus mykiss*) (Boag 1987). Bull trout above the dam may have lacked access to small salmonids or found Ephemeroptera to be abundant and easily taken. Below the dam complex rainbow trout were important prey, particularly in May and June. While Ephemeroptera were present in the river in May and June, they were not found in the diet until July and August, when they were important prey. The dietary differences between bull trout in the upper and lower reaches of the river illustrate the species' opportunistic feeding habits.

In Chester Morse Lake, Washington, which is 42 m deep, adult bull trout were found in the **littoral**, **pelagic** and **profundal** zones (Connor *et al.* 1997). Food items appear to be derived from all areas of the lake. In Harrison Lake, Alberta, the small fish (≤ 250 mm) feed in shallow water (< 1 m deep) while the larger fish (> 250 mm) feed in the profundal offshore zone (Wilhelm *et al.* 1999). The presence of stones and clams (*Pisidium* spp.) in stomachs with *Gammarus lacustris* suggest that these fish are benthic feeders.

2.2.3 Latitude and elevation

Bull trout populations are distributed across a broad range of latitudes and elevations, where they prey opportunistically on available species (Appendix 1; Appendix 2). While the individual prey species change somewhat, the general taxonomic groupings preyed upon by each life stage are similar across these ranges. The greatest exceptions to this may be related to the presence and absence of fish prey.

Where other fish species are absent, typically in the highest reaches of the stream habitats or in isolated mountain lakes, adult bull trout prey mostly on invertebrates but will also eat smaller bull trout (Boag 1987; Wilhelm *et al.* 1999). This dietary difference is reflected in their slower growth to a smaller maximum size.

2.2.4 Season

Seasonal changes in bull trout diet have not been documented in detail. Because the species' diet shifts in response to changing prey availability (Boag 1987; Wilhelm *et al.* 1999), bull trout will follow an annual dietary cycle that follows the seasonal abundance of their prey. Sometimes what appears to be a seasonal shift in diet, such as the apparent shift to eating more yellow perch in winter in Flathead Lake (Appendix

1) may be an artefact of sampling location (Leathe and Graham 1981). Feeding is likely heaviest during the open water period, when aquatic insect production peaks, and ice cover does not limit the entry of terrestrial biota into the water.

The seasonality of bull trout predation is closely coupled to the long-term viability of their prey species. After ice-out in July, small (≤ 250 mm FL) and large (≥ 250 mm FL) bull trout in Harrison Lake, a small alpine lake in Alberta, feed on seasonally abundant prey species (Wilhelm *et al.* 1999). They feed heavily on chironomid pupae, *Daphnia pulex* var., and the amphipod *Gammarus lacustris*. Populations of these invertebrate species are cropped (eaten) after they have reproduced. Prey switching, timing of prey reproduction and spatial segregation of the fish population by size, are tightly coupled and contribute to the survival of the key prey species.

2.3 Interspecific competition

Adfluvial bull trout populations in lakes that do not have restricted access, and that have been stocked with other *Salvelinus* species, are particularly vulnerable to extirpation by the combined effects of harvesting pressure and interspecific competition and/or predation (Donald and Stelfox 1997).

The introduction of lake trout (*Salvelinus namaycush*), brook trout (*Salvelinus fontinalis*), or their hybrids (splake) can displace bull trout, and may prevent them from becoming established in certain low-elevation lakes (Donald and Alger 1993; Donald and Stelfox 1997). In Bow Lake, Alberta, for example, the introduction of lake trout in 1964 decimated the bull trout population by 1992. Niche overlap with respect to food utilization and growth is substantial between bull trout and lake trout. Competition may contribute to the disjunct distribution of these species, which likely prey opportunistically on one another (Donald and Alger 1993).

Sympatric bull trout and lake trout use similar foods in a variety of mountain lake types (Donald and Alger 1993). In lakes with a simple trophic structure (those with only char and no amphipods or mysids), chironomids and aerial insects are important food items common to both species. In lakes where mountain whitefish are present and amphipods are part of the benthic community (e.g., Hector and Southesk lakes), bull trout and lake trout feed primarily on chironomids, amphipods, mountain whitefish, and aerial insects. In lakes with a complex trophic structure (those with several fish species and amphipods and mysids), both bull trout and lake trout are primarily piscivorous.

Competitive interactions with brook trout may be an important factor in the mechanism responsible for the regulation of bull trout densities in tributary streams, at least on a local scale (Nakano *et al.* 1998). Stocking bull trout streams with hatchery reared steelhead trout (*Oncorhynchus mykiss*) and chinook salmon (*O. tshawytscha*)

may slow bull trout growth (Underwood *et al.* 1995). Removal or suppression of introduced species to promote bull trout recovery is difficult (Montana Bull Trout Scientific Group 1995).

Significant dietary overlap has been observed between bull trout and steelhead trout in Washington State streams, where food resources were not limiting (Underwood *et al.* 1995). Whether the species shift their diets to avoid competition when food resources become limiting is unknown. Juvenile bull trout use different foraging strategies and occupy different microhabitats than sympatric cutthroat trout (*O. clarkii*) (Nakano *et al.* 1992).

3.0 SUMMARY

Bull trout are opportunistic predators. Throughout their distribution, both adults and juveniles eat a wide variety of seasonally available macroinvertebrate taxa, at various life stages (eggs, larvae, pupae, nymphs, adults), that originate from both aquatic and terrestrial habitats. Juvenile bull trout become increasingly piscivorous as they approach adulthood; adult populations in some lakes are highly piscivorous and will migrate downstream to prey upon spawning kokanee. Humans may be the key predator on adult and large juvenile bull trout, while piscivorous fishes, particularly lake trout and large bull trout, may be the key predators on smaller juveniles. Competition for food with other species of trout and salmon may be a factor in the displacement of bull trout from some lake habitats, and may limit their growth in some stream habitats.

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6.0 GLOSSARY

Adfluvial fish populations move between lake and river or stream environments.

Fluvial fish populations remain in rivers and streams throughout their lives.

Littoral species occupy habitats that are near the shore.

Macroinvertebrates are animals that lack a backbone (i.e., invertebrates) and are big enough to be seen by the naked eye (e.g., insects larvae and crayfish).

Pelagic species occupy habitats that are not near the bottom or shore.

Piscivorous species eat fish.

Profundal species occupy deep water habits near the lake bottom, below the effective depth of light penetration.

Sympatric species occur in the same or overlapping areas.

7.0 APPENDICES

Stomach contents of bull trout from streams and lakes of Washington (WA), Montana (MT), and British Columbia (BC) are summarized in Appendix 1 and from Alberta (AB) are summarized in Appendix 2.

Key to Appendices 1 and 2:

+ = present in small amounts;

P = present in the diet but not quantified.

***** = fish are considered to be age 0 until December 31 of the year they are born.

References:

1 = Boag 1987

2 = Donald and Alger 1993

3 = Fraley and Shepard 1989

4 = Hagen and Taylor 2001

5 = Mushens and Post 2000

6 = Wilhelm *et al.* 1999

7 = Underwood *et al.* 1995

Notes:

a = Lengths cited by Boag (1987) as mm were likely cm.

b = Other includes: Annelida, Insecta - Orthoptera (Locustidae), Hemiptera (Corixidae), Coleoptera, Hymenoptera (Vespidae, Formicidae), and Crustacea - amphipoda.

c = Indices of Relative Importance (IRI) = (%VOLUME + %Total items) (%Frequency); maximum value = 20000 = (100+100) x 100

d = % wet wt.

e = % of total points for all fish based on Hynes (1950) points method.

f = % by volume.

g = The only fish species in lake.

h = % taxonomic composition.

i = Based on August 1996 data, Table 1 of Wilhelm *et al.* (1999), mean volume estimated by the points method based on food found in non-empty stomachs.

j = Index of Relative Importance (IRI) (George and Hadley 1979), expressed as a percentage.

Appendix 1. Prey of bull trout in streams and lakes of Washington (WA), Montana (MT), and British Columbia (BC). See above for explanatory key.

	Mill Creek, WA	Tucannon River, WA	Wolf Fork, WA	Flathead Lake, MT		Thutade Lake, BC	
Season	Jul-Aug	Jun.-Aug.	Jun.-Aug.	Nov.-Jan.	May-Oct.	Jun.	
Coordinates	46°02'19"N, 118°28'43"W	46°33'28"N, 118°10'35"W	46°16'27"N, 117°53'45"W	47°41'N, 114°14'W		56°53'N, 126°59'W	
Elevation (m asl)	>144	>147	>580	882		~1300	
Life history type	fluvial	fluvial	fluvial	adfluvial	adfluvial	adfluvial	
Life stage (J = juvenile; A = Adult)	J	J	J	J, A	J, A	J	A
Age range*		0 - 3 (otolith)					
Length range (mm)	30-270 mm FL	30-225 mm FL	35-185 mm FL			~50-150	410-800
# of stomachs examined (# empty)	10	23	107	95	201	24	3
Invertebrates							
Ph. Annelida							
SubCl. Oligochaeta (worms)	0.9	10.2	4.9				
Ph. Arthropoda							
Cl. Arachnida (arachnids)	1.7	1.5	2.8				
Cl. Diplopoda (millipedes)			1.3				
Cl. Insecta (insects)							
O. Coleoptera (beetles)	3.7	0.7	0.9			5.5	
O. Diptera (gnats, mosquitos, flies)	5.0	6.1			+	25.6	
F. Chironomidae (midges)	13.5	11.8	12.9		+		
F. Simuliidae (blackflies, gnats)	8.9	0.7	8.4				
F. Tipulidae (crane flies)	2.0	0.8	2.3				
O. Ephemeroptera (mayflies)	29.5	26.6	37.2		+	46.2	
O. Hemiptera (true bugs)	2.1	1.5	2.1				
F. Corixidae (water boatmen)							

Appendix 1. Continued.

	Mill Creek, WA	Tucannon River, WA	Wolf Fork, WA	Flathead Lake, MT		Thutade Lake, BC
O. Hymenoptera (ants, bees, wasps)	2.1	1.5	7.9			0.6
O. Lepidoptera (butterflies, moths)	2.5	1.5	1.2			
O. Megaloptera (fish flies)	0.8					
O. Plecoptera (stoneflies)	6.2	6.4	3.2			10.6
O. Trichoptera (caddisflies)	8.8	16.1	15.0		+	11.4
SubPh. Crustacea		0.7				
O. Amphipoda (e.g., *Gammarus*)					+	
SubO. Cladocera (water fleas)					+	
F. Mysidacea (opposum shrimp)						
Mysis sp.						
Ph. Mollusca						
Cl. Bivalvia (clams)						
F. Pisidiidae (pea clams; was F. Sphaeriidae)						
Pisidium spp.						
Cl. Gastropoda (snails)						
Lymnaea sp.						
Other invertebrates						
Amphibians						
F. Ranidae (frogs)		14.0				
Fishes				38.8	32.0	
F. Cyprinidae (minnows)						
Richardsonius balteatus (redside shiner)				1.9		
Mylocheilus caurinus (peamouth)				0.7		
F. Catostomidae (suckers)				3.5		
Catostomus catostomus (longnose sucker)						
F. Salmonidae (grayling, salmon, trout, whitefish)						

Coregonus clupeaformis (lake whitefish)				4.0	25.0		
Oncorhynchus clarkii (cutthroat trout)							
Oncorhynchus mykiss (rainbow trout)							
Oncorhynchus nerka (kokanee)				3.8	18.0		P
Prosopium coulteri (pygmy whitefish)				3.0			
Prosopium williamsoni (mountain whitefish)				4.1	25.0		P
unidentified trout/salmon	10.9			1.4			
unidentified whitefish				14.1			
F. Gasterosteidae (sticklebacks)							
Culaea inconstans (brook stickleback)							
F. Cottidae (sculpins)	1.4			1.7			
F. Percidae (perch)							
Perca flavescens (yellow perch)				23.1			
Fish eggs							
Detritus							
Other items (unspecified)							
Reference:	7	7	7	3	2	4	4
Notes:	j	j	j	c	e	h	

Appendix 2. Prey of bull trout in streams and lakes of Alberta (AB). See above for explanatory key.

		Muskeg River, AB		Miette Lake, AB	Southesk Lake, AB	Hector Lake, AB	Glacier Lake, AB	Lower Kananaskis Lake, AB	Harrison Lake, AB
Season	May-Jun.	Jul.-Aug.	Jul.-Aug.	Sep.	Jul.	Aug.	Jul.		Aug.
Coordinates		54°01'N, 119°03'W		53°00'N, 118°37'W	52°38,N, 117°12'W	51°35'N, 116°21'W	51°55'N, 116°51'W	50°37'N, 115°08'W	51°32'N 115°48'W
Elevation (m asl)				1865	1830	1752	1433	1667	2243
Life history type	unknown	unknown	resident	adfluvial	adfluvial	adfluvial	adfluvial	adfluvial	adfluvial
Life stage (J = juvenile; A = Adult)	J, A	J, A	J, A	J, A	J, A	J, A	J, A		J, A
Age range*	2 - 8 (scales)								
Length range (mm)	180 - 460 mm FL								250-450
# of stomachs examined (# empty)	50 (17)			23	22	10	23	107	36 (6)
Invertebrates									
Ph Annelida									
SubCl. Oligochaeta (worms)									
Ph. Arthropoda									
Cl. Arachnida (arachnids)									
Cl. Diplopoda (millipedes)									
Cl. Insecta (insects)									
O. Coleoptera (beetles)									
O. Diptera (gnats, mosquitos, flies)	1.9	8.6	12.4	8.0	1.3	23.8	29.0	P	1.7
F. Chironomidae (midges)				37.0	17.7	15.2	6.0		43.0
F. Simuliidae (blackflies, gnats)									
F. Tipulidae (crane flies)									
O. Ephemeroptera (mayflies)		64.1	63.5	53.0	1.3	1.0	11.0		
O. Hemiptera (true bugs)									

F. Corixidae (water boatmen)									1.7
O. Hymenoptera (ants, bees, wasps)									
O. Lepidoptera (butterflies, moths)									
O. Megaloptera (fish flies)									
O. Plecoptera (stoneflies)	15.4	7.3	12.3						
O. Trichoptera (caddisflies)	0.3	0.5	1.7	1.0	5.1		11.0		+
SubPh. Crustacea									+
O. Amphipoda (e.g., *Gammarus*)					31.6	36.2		P	52.1
SubO. Cladocera (water fleas)				0.0		23.8	8.0		
F. Mysidacea (opposum shrimp)									
Mysis sp.								P	
Ph. Mollusca									
Cl. Bivalvia (clams)									
F. Pisidiidae (pea clams; was F. Sphaeriidae)				+					
Pisidium spp.									1.7
Cl. Gastropoda (snails)									
Lymnaea sp.							+		
Other invertebrates	9.4	7.4	9.0						
Amphibians									
F. Ranidae (frogs)									
Fishes									
F. Cyprinidae (minnows)									
Richardsonius balteatus (redside shiner)									
Mylocheilus caurinus (peamouth)									
F. Catostomidae (suckers)									
Catostomus catostomus (longnose sucker)								P	
F. Salmonidae (grayling, salmon, trout, whitefish)									
Coregonus clupeaformis (lake hitefish)									
Oncorhynchus clarkii (cutthroat trout)								P	
Oncorhynchus mykiss (rainbow trout)	70.8	12.1							

Appendix 2. Continued.

	Muskeg River, AB			Miette Lake, AB	Southesk Lake, AB	Hector Lake, AB	Glacier Lake, AB	Lower Kananaskis Lake, AB	Harrison Lake, AB
Oncorhynchus nerka (kokanee)									
Prosopium coulterii (pygmy whitefish)									
Prosopium williamsoni (mountain whitefish)					34.2		34.0		
unidentified trout/salmon									
unidentified whitefish									
F. Gasterosteidae (sticklebacks)									
Culaea inconstans (brook stickleback)								P	
F. Cottidae (sculpins)									
F. Percidae (perch)									
Perca flavescens (yellow perch)									
Fish eggs	0.3								
Detritus	1.9		1.1						
Other items (unspecified)				1.0	8.9		1.0		
Reference:	1	1	1	2	2	2	2	5	6
Notes:	a,b,c	a,b,c	a,b,c	e, g	e	f	f	d	i